of Laye (4) and Manna, were all cracked by them; and the works at the ſugar-plantation (5) received conſiderable damage. The ground opened near the *qualloe* (6) at Bencoolen, and up the River in ſeveral places; and there iſſued therefrom ſulphureous earth, and large quantities of water, ſending forth a moſt intolerable ſtench. Poblo Point (7) was much cracked at the ſame time; and ſome *dooſoons* (8) in-land at Manna were deſtroyed, and many people in them.

Theſe are all the ill effects, that have come to our knowlege; but, it is reaſonable to ſuppoſe, not all the damage, that has happened upon the iſland.

LXIII. *Concerning the Fall of Water under Bridges. By Mr.* J. Robertſon, *F.R.S.*

Read Jan. 19, 1758.

SOME time before the year 1740, the problem about the fall of water, occaſioned by the piers of bridges built acroſs a river, was much talked of at London, on account of the fall that it was ſuppoſed would be at the new bridge to be built at Weſtminſter. In Mr. Hawkſmore's and Mr. Labelye's pamphlets, the former publiſhed in 1736,

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(4) Laye houſe or factory is about 30 miles to the northward of Marlborough, and Manna houſe or factory fifty miles to the ſouthward.

(5) The ſugar-plantation is five or ſix miles from Marlborough.

(6) The *qualloe* is the country word for a river's mouth.

(7) Poblo Point lies about three leagues to the ſouthward of Marlborough.

(8) *Dooſoons* are villages.

1736, and the latter in 1739, the reſult of Mr. Labelye's computations was given: but neither the inveſtigation of the problem, nor any rules, were at that time exhibited to the public.

In the year 1742 was publiſhed Gardiner's edition of Vlacq's Tables; in which, among the examples there prefixed to ſhew ſome of the uſes of thoſe tables drawn up by the late William Jones, Eſq; there are two examples, one ſhewing how to compute the fall of water at London-bridge, and the other applied to Weſtminſter-bridge: but that excellent mathematician's inveſtigation of the rule, by which thoſe examples were wrought, was not printed, altho' he communicated to ſeveral of his friends copies thereof. Since that time, it ſeems as if the problem had in general been forgot, as it has not made its appearance, to my knowlege, in any of the ſubſequent publications. As it is a problem ſomewhat curious, tho' not difficult, and its ſolution not generally known (having ſeen four different ſolutions, one of them very imperfect, extracted from the private books of an office in one of the departments of engineering in a neighbouring nation), I thought it might give ſome entertainment to the curious in theſe matters, if the whole proceſs were publiſhed. In the following inveſtigation, much the ſame with Mr. Jones's, as the demonſtrations of the principles therein uſed appeared to be wanting, they are here attempted to be ſupplied.

PRINCIPLES.

I. *A heavy body, that in the firſt ſecond of time has fallen the height of* a *feet, has acquired ſuch a velocity,*

locity, that, moving uniformly therewith, will in the next second of time move the length of 2 a feet.

II. *The spaces run thro' by falling bodies are proportional to one another as the squares of their last or acquired velocities.*

These two principles are demonstrated by the writers on mechanics.

III. *Water forced out of a larger chanel thro' one or more smaller passages, will have the streams thro' those passages contracted in the ratio of 25 to 21.*

This is shewn in the 36th prop. of the 2d book of Newton's Principia.

IV. *In any stream of water, the velocity is such, as would be acquired by the fall of a body from a height above the surface of that stream.*

This is evident from the nature of motion.

V. *The velocities of water thro' different passages of the same height, are reciprocally proportional to their breadths.*

For, at some time, the water must be delivered as fast as it comes; otherwise the bounds would be overflowed.

At that time, the same quantity, which in any time flows thro' a section in the open chanel, is delivered in equal time thro' the narrower passages; or the momentum in the narrow passages must be equal to the momentum in the open chanel; or the rectangle under the section of the narrow passages, by their mean velocity, must be equal to the rectangle under the section of the open chanel by its mean velocity.

Therefore

Therefore the velocity in the open chanel is to the velocity in the narrower paſſages, as the ſection of thoſe paſſages is to the ſection of the open chanel.

But the heights in both ſections being equal, the ſections are directly as the breadths;

Conſequently the velocities are reciprocally as the breadths.

VI. *In a running ſtream, the water above any obſtacles put therein will riſe to ſuch a height, that by its fall the ſtream may be diſcharged as faſt as it comes.*

For the ſame body of water, which flowed in the open chanel, muſt paſs thro' the paſſages made by the obſtacles:

And the narrower the paſſages, the ſwifter will be the velocity of the water:

But the ſwifter the velocity of the water, the greater is the height, from whence it has deſcended:

Conſequently the obſtacles, which contract the chanel, cauſe the water to riſe againſt them.

But the riſe will ceaſe, when the water can run off as faſt as it comes:

And this muſt happen, when, by the fall between the obſtacles, the water will acquire a velocity in a reciprocal proportion to that in the open chanel as the breadth of the open chanel is to the breadth of the narrow paſſages.

VII. *The quantity of the fall cauſed by an obſtacle in a running ſtream is meaſured by the difference be-*

tween

tween the heights fallen from to acquire the velocities in the narrow paſſages and open chanel.

For juſt above the fall, the velocity of the ſtream is ſuch, as would be acquired by a body falling from a height higher than the ſurface of the water:

And at the fall, the velocity of the ſtream is ſuch, as would be acquired by the fall of a body from a height more elevated than the top of the falling ſtream; and conſequently the real fall is leſs than this height.

Now as the ſtream comes to the fall with a velocity belonging to a fall above its ſurface;

Conſequently the height belonging to the velocity at the fall muſt be diminiſhed by the height belonging to the velocity, with which the ſtream arrives at the fall.

PROBLEM.

In a chanel of running water, whoſe breadth is contracted by one or more obſtacles; the breadth of the chanel, the mean velocity of the whole ſtream, and the breadth of the water-way between the obſtacles being given; To find the quantity of the fall occaſioned by thoſe obſtacles.

Let $b =$ breadth of the chanel in feet.
$v =$ mean velocity of the water in feet per ſec.
$c =$ breadth of the water-way between the obſtacles.

Now $25 : 21 :: c : \frac{21}{25} c$ the water-way contracted. . . . . *Principle* III.

And

And $\frac{21}{25}c : b :: v : \frac{25b}{21c}v$ the veloc. *per* fec. in the water-way between the obftacles. . . *Princip.* V.

Alfo $\overline{2a}^2 : vv :: a : \frac{vv}{4a}$ the height fallen to acquire the vel. v. . . . . I. & II.

And $\overline{2a}^2 : \overline{\frac{25b}{21c}}^2 \times vv :: a : \overline{\frac{25b}{21c}}^2 \times \frac{vv}{4a}$ the height fallen to acquire the vel. $\frac{25b}{21c}v$. . . . . . . I. & II.

Then $\overline{\frac{25b}{21c}}^2 \times \frac{vv}{4a} - \frac{vv}{4a}$ is the meafure of the fall required. . . . . VII.

Or $\overline{\overline{\frac{25b}{21c}}^2 - 1} \times \frac{vv}{4a}$ is a rule, by which the fall may be readily computed.

Here $a = 16,0899$ feet and $4a = 64,3596$.

Example I. *For London-Bridge.*

By the obfervations made by Mr. Labelye in 1746,

The breadth of the Thames at London-bridge is 926 feet;

The fum of the water-ways at the time of the greateft fall is 236 feet;

The mean velocity of the ftream taken at its furface juft above bridge is $3\frac{1}{6}$ feet *per* fecond.

Under almoft all the arches there are great numbers of drip-fhot piles, or piles driven into the bed of the water-way, to prevent it from being wafhed away by the fall. Thefe drip-fhot piles confiderably contract the water-ways, at leaft $\frac{1}{6}$ of their meafured breadth, or about $39\frac{1}{3}$ feet in the whole.

 So

So that the water-way will be reduced to $196\frac{2}{3}$ feet.

Now $b = 926$; $c = 196\frac{2}{3}$; $v = 3\frac{1}{6}$; $4a = 64{,}3596$.

Then $\frac{25b}{21c} = \frac{23150}{4130} = 5{,}60532$

And $\overline{5{,}60532}|^2 = 31{,}4196$; and $31{,}4196 - 1 = 30{,}4196 = \overline{\frac{25b}{21c}}|^2 - 1$.

Alſo $vv = \overline{\frac{19}{6}}|^2 = \frac{361}{36}$; And $\frac{vv}{4a} = \frac{361}{36 \times 64{,}3596} = 0{,}15581$.

Then $30{,}4196 \times 0{,}15581 = 4{,}739$ feet, the fall ſought after.

By the moſt exact obſervations made about the year 1736, the meaſure of the fall was 4 feet 9 inches.

Example II. *For Weſtminſter-Bridge.*

Altho' the breadth of the river at Weſtminſter-bridge is 1220 feet; yet, at the time of the greateſt fall, there is water thro' only the thirteen large arches, which amount to 820 feet: to which adding the breadth of the twelve intermediate piers, equal to 174 feet, gives 994 for the breadth of the river at that time: and the velocity of the water juſt above bridge (from many experiments) is not greater than $2\frac{1}{4}$ feet *per* ſecond.

Here $b = 994$; $c = 820$; $v = 2\frac{1}{4}$; $4a = 64{,}3596$.

Now $\frac{25b}{21c} = \frac{24850}{17220} = 1{,}443$.

And

And $\overline{1{,}443}|^2 = 2{,}082$; And $2{,}082 - 1 = 1{,}082$
$= \overline{\frac{25\,b}{21\,c}}\Big|^2 - 1.$

Alſo $v\,v = \overline{\frac{9}{4}}\Big|^2 = \frac{81}{16}$; And $\frac{v\,v}{48} = \frac{81}{16 \times 64{,}3596} =$
$0{,}0786$.

Then $1{,}082 \times 0{,}0786 = 0{,}084$ feet, the fall ſought.

Which is about 1 inch; and is about half an inch more than the greateſt fall obſerved by Mr. Labelye.

LXIV. *An Account of the Earthquake in the Weſt Parts of* Cornwall, July 15*th* 1757. *By the Rev.* William Borlaſe, *M. A. F. R. S. Communicated by the Rev.* Charles Lyttelton, *LL. D. Dean of* Exeter, *F. R. S.*

Read Jan. 26. 1758.

ON Friday the 15th of July, 1757. a violent ſhock of an earthquake was felt in the weſtern parts of Cornwall.

The thermometer had been higher than uſual, and the weather hot, or calm, or both, for eight days before; wind eaſt and north-eaſt. On the 14th in the morning, the wind ſhifting to the ſouth-weſt, the weather calm and hazy, there was a ſhower. The afternoon hazy and fair, wind north-weſt. The barometer moderately high, but the mercury remarkably variable.